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EXPERIMENTS ON THE PREPARATION OF SUGARED, DRIED PINEAPPLES.

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INTRODUCTION.

At the suggestion of Mr. William A. Taylor, Pomologist in Charge of Field Investigations, Bureau of Plant Industry, and in cooperation with him, experiments on the preparation of sugared, dried pineapples were undertaken in July, 1909. A method of sugaring and drying of much promise has been developed, but another season's study is necessary before the final recommendations can be made.

The first trials were made with a few Red Spanish pineapples. The fruits were sliced and dried with and without previous steaming, using no sugar. The results, though favorable, were not entirely satisfactory. An experiment in sugaring was then tried, and so attractive a product resulted that the succeeding work consisted mainly in developing the best method of applying the sugar.

DESCRIPTION OF THE DRIER.

The drier consisted of a steam-heated chamber 8 feet high, 3 feet wide, and 2.5 feet deep, inside measurements, provided with steam coils and ventilators. It was operated out-of-doors. Four steam coils were used, two at the bottom, one a little below the center, and one just above the center of the drier. With the ventilators open, three different temperatures could be obtained, if desired, by placing the material to be dried on trays in different parts of the drier. The pineapples were generally dried at temperatures between 60° and 70° C., never exceeding 75°. A diaphragm valve was used, operated by compressed air and controlled by a suitable regulator. The temperatures were in this way easily kept within the desired limits. As an

additional precaution to prevent scorching in case of failure of the compressed-air supply, a reducing valve was also used.

The slatted trays of cypress, 3 feet long by 2 feet wide, when placed in the drier were so arranged that the alternate trays touched the rear wall, leaving a 6-inch space in front, while the others touched the door, leaving a 6-inch space in the rear. The air currents could thus cir-

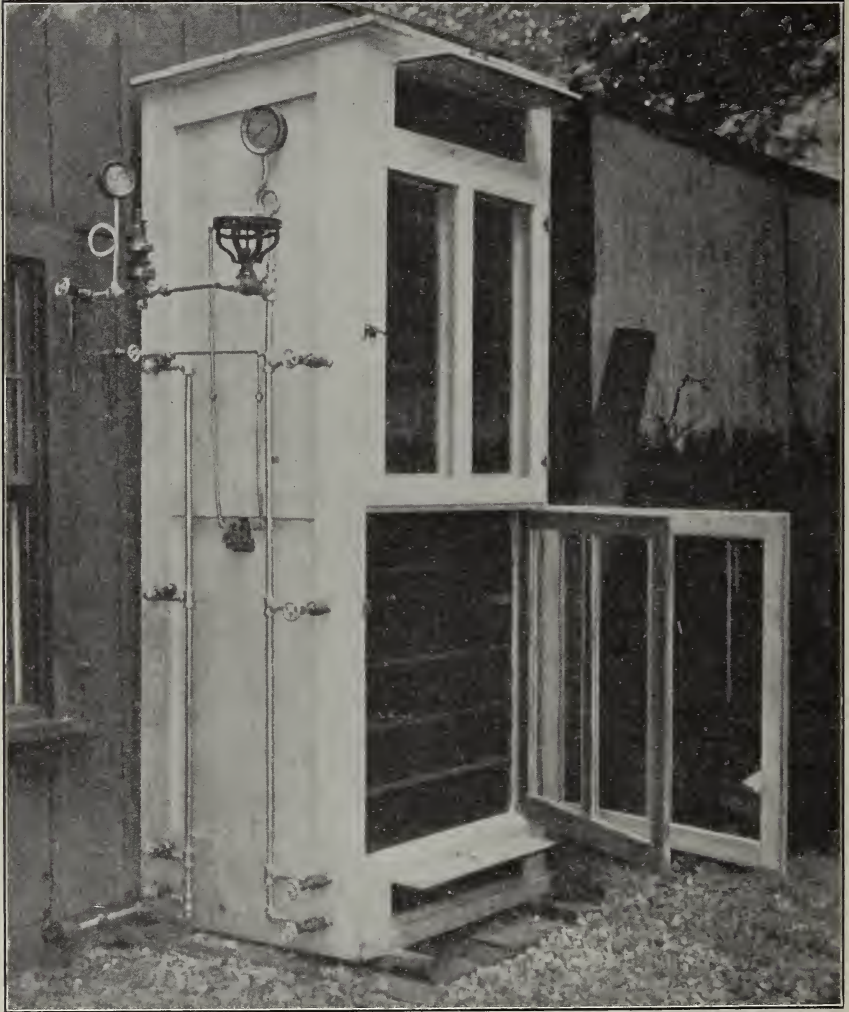


FIG. 1.—Fruit drier.

culate back and forth through the drier, as well as through the trays. The fruit, however, did not dry very evenly, because of the uneven heating caused by the distribution of the steam coils. For drying on a large scale the coils should all be located at the bottom of the drier.

DESCRIPTION OF EXPERIMENTS.

EXPERIMENT 1, JULY 30, 1909.

In this experiment Red Spanish pineapples were dried with and without previous steaming and no sugar was used. The fruit was trimmed by cutting off the crowns, base slices, and the outside of the pips. They were then cut into round slices about three-eighths of an inch thick, weighed, and spread in single layers on trays. The steaming was conducted in a shallow box of galvanized iron in which the trays carrying the sliced fruit were placed. The fruit was then dried for about nineteen hours at from 65° to 70° C. The original weights of the fruit slices, time of steaming, and yields of dried fruit were as follows:

Weight of fresh fruit compared with that of dried product.

Weight of fruit slices.		Time of steaming.	Weight of yield.	
<i>Grams.</i>	<i>Minutes.</i>		<i>Grams.</i>	<i>Per cent.</i>
1,200	0		167	13.92
1,200	5		154	12.83
2,030	10		233	11.48

The unsteamed dried slices were opaque and of a very pale-yellow color, almost white. The two lots of steamed dried fruit were translucent and of a much darker yellow. All of the fruit was considerably overdried. The slices held their shape well during drying and were rich in pineapple flavor. They were brittle, acid, and not very palatable on account of lack of sugar.

EXPERIMENT 2, JULY 30, 1909.

In this case the fruit was dried after standing with sugar. Slices of the same lot of fruit used in Experiment 1 were packed in layers with granulated sugar in an open-top, enamel-lined tin can about 6 inches in diameter and 7 inches high, provided with a tightly fitting cover. The slices weighed 1,827 grams and 1 kilogram of sugar was used. The fruit and sugar were allowed to stand overnight, a period of about nineteen hours. During this time the slices contracted in volume and the sugar disappeared. Much sirup formed, consisting of sugar dissolved in juice. This sirup weighed 1,230 grams, equal to 43.5 per cent of the slices and sugar. The sugared slices were placed on trays and dried for about fifteen hours at from 65° to 70° C. After drying they weighed 532 grams, equal to 29.1 per cent of the original pulp. The dried product was soft, sugary, and delicious in flavor, retaining fully the aroma and taste of the pineapple. The color

was a rich golden yellow. The fibrovascular bundles of the cores and "eyes" were very prominent, indicating that both should be trimmed away before drying.

On keeping in tightly closed glass jars the slices stiffened, owing to crystallization of the sugar, the aroma became rather less strong, and the color changed to a light golden brown, not objectionable but less attractive than the yellow. The flavor remained very delicious. The sirup was yellow, rather acid in taste, and finely flavored. It was kept in jars and after a few days began to ferment slowly.

Dried, sugared pineapple was the product desired rather than sirup, and the subsequent experiments were planned so as to develop a method of sugaring by which the dried, sugared fruit would be produced with the formation of but little sirup. It was proposed to dry the slices partly before sugaring, and to use less sugar. Mr. Taylor suggested that the Smooth Cayenne variety probably would be more suitable for drying than the Red Spanish, because it is less fibrous and a larger proportion of each fruit can be obtained in the form of large perfect rings.

EXPERIMENT 3, AUGUST 12, 1909.

In accordance with these suggestions the slices were dried for varying periods before mixing with sugar and different quantities of sugar were added to the several lots of sliced fruit. Smooth Cayenne pineapples were employed, large specimens rather unevenly ripened being used. The fruits were trimmed and sliced as before, except that the "eyes" and cores were removed, and powdered sugar was used in this and in subsequent experiments.

The methods of packing in sugar and drying were similar to those used in Experiment 2. The data obtained in this and the following experiments are given in the table. It is shown that the amount of sirup formed can be greatly lessened by partly drying before sugaring and that much less sugar is required. The yield of sugared dried slices, however, is also less. The sirup ferments readily, and if it is produced in large quantity, provision must be made for sterilizing the juice and keeping it sterile. If, on the other hand, relatively small quantities are produced, it might be utilized in sugaring partly dried fruit. The sirup is so delicious that it would probably find a ready market in the confectionery and soft-drink trades.

The total solid content of the sirups (calculated as sugar from the refractometer readings by the tables of Geerligs^a) showed, as would be expected, that they varied widely in composition according to the time of drying and the amounts of sugar used.

^a U. S. Dept. Agr., Bureau of Chemistry Cir. 43, p. 7; Bul. 122, p. 169.
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The final products of the seven lots in Experiment 3 were very palatable and very similar in flavor. Mr. Taylor's comments indicate that pineapple pulp considerably dried before sugaring is superior in flavor and texture to pulp undried or only slightly dried before sugaring; lots 4 and 7 seemed to be the best, and a partial analysis showed their composition to be very similar. While the time of drying before sugaring varied widely in these two cases, the amounts of added sugar were nearly the same.

Partial analysis of the two best products from Experiment 3. (A. L. Davison.)

Lot number.	Solids.	Reducing sugar as invert.	Total sugar as invert.	Sucrose.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
4	89.74	22.8	77.9	52.4
7	90.88	23.3	76.1	50.2

The seven lots were kept in tightly closed glass jars from August 16 to September 20, at laboratory temperatures. Then each one was pressed into brick form and kept in a small wooden box, which was well wrapped in paper to exclude insects. All of the samples kept perfectly sound through the winter, but gradually became desiccated, the color darkening to a light yellowish brown. The delightful pineapple aroma, considerably stronger than that of fresh pineapples, persisted without perceptible change during the period of storage in the tight jars, but gradually lessened during keeping in the boxes.

Lot No. 7 was probably the most successful from all points of view. Less sirup was formed than in any of the other cases except No. 6, which was insufficiently sugared, and the slices contained enough sugar so that the texture and flavor were excellent. No. 4 was also very palatable, but more sirup formed than in the case of No. 7.

EXPERIMENT 4, AUGUST 28, 1909.

The method of drying before sugaring, employed in Experiment 3, No. 7, was applied to Red Spanish pineapples, using 1.358 kilograms of fruit pulp. The period of standing in contact with sugar was forty-two hours, a longer time than is necessary. The separation of sirup and sugared slices was not complete, as the slices readily released sirup when handled, and much more could have been obtained by using slight pressure. The finished product was pliable and slightly sticky, but became sugary on keeping.

EXPERIMENT 5, AUGUST 30, 1909.

The method of drying used in Experiment 4 was again tried, with slight changes, using 10.8 kilograms of Red Spanish pulp. The

sugared fruit slices, prepared as in Experiments 4 and 5, were kept in tight glass jars until September 20, when they were pressed into half-pound bricks and stored in small wooden boxes, as in Experiment 3. The products remained perfectly sound, but in all cases the fine golden yellow color gradually changed to a light brown.

EXPERIMENT 6, OCTOBER 15, 1909.

This experiment was carried out as in the case of Experiments 4 and 5, except that an attempt was made to incorporate the sirup which separated, by mixing it with the finished product, allowing it to stand for two days, and redrying. The experiment was only partly successful, as a large part of the sirup taken up by the slices dripped off in the drier.

EXPERIMENT 7, OCTOBER 16, 1909.

In this experiment there was an attempt to reincorporate the sirup by prolonging the time of standing after mixing. Very little sirup was taken up, and the experiment was not carried to completion. While it is possible to add the separated sirup to the dried fruit, it is probably better to avoid its formation as far as possible, on account of the danger of fermentation during the time the fruit and sirup are in contact.

EXPERIMENT 8, OCTOBER 19, 1909.

A set of tests was undertaken at the suggestion of Doctor Bigelow to determine whether the formation of sirup could be prevented by carrying the preliminary drying further before sugaring. The data are shown in the table, the two sets of experiments 8a and 8b having been made with fruit grown at two localities in Florida.

The very long period in contact with sugar—one hundred and thirty-seven hours—was required because the slices, which were rather overdried, took up sugar very slowly. One of the samples, No. a-4, fermented perceptibly during this period and lost considerably in quality. Such a long interval of sugaring is not desirable, and a period of about sixteen hours will usually be sufficient. Experiment 8, as a whole, shows that sirup formation can be nearly if not entirely eliminated.

The dried slices from Experiments 4 to 8, inclusive, were pressed into bricks and placed in small wooden boxes. With the exception of the samples sent to cold storage at 32° F., the boxes were kept in museum jars at room temperature. An examination of these samples made on March 3, 1910, showed that all were perfectly sound, and very attractive in appearance and flavor. They had lost some-

what in aroma and had shrunk slightly, indicating that the jars were not perfectly air-tight, though provided with rubber gaskets. The dried product from the Red Spanish pineapples darkened during storage considerably more than that prepared from the Smooth Cayenne. The dried sugared slices kept in cold storage consisted of mixed samples from Experiments 6 and 7. When examined on March 3 they were found to be rich in pineapple aroma and flavor, and had not darkened perceptibly, retaining their original golden yellow color.

Dried, sugared pineapples should find a ready sale if a steady supply of uniform quality can be placed on the market.

SUMMARY.

1. The principal fact developed in this work is that sliced pineapples when dried and sugared yield a very palatable product of fine keeping quality.

2. Since sliced pineapples when allowed to stand in contact with sugar form a large quantity of sirup, it is advisable to dry them until from 65 to 75 per cent of the weight has been lost, and then allow the partly dried slices to stand in contact with about 12 per cent of their weight of sugar for from six to eighteen hours. During this period some sirup may be expected to separate. The slices are then to be redried until they appear fairly firm but are still slightly sticky.

3. The sugared, dried pineapples darken slightly on keeping, the Red Spanish variety darkening considerably more than the Smooth Cayenne. In the case of the Red Spanish, this darkening was prevented to a very large extent by keeping in cold storage.

TABULATED DATA.

The following table presents in detail the varying conditions under which the several experiments were performed and gives the yields of dried slices and of sirup in each case. The results of the organoleptic tests made by Mr. Taylor are given in the footnotes.

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Conditions of experiments with dried, sugared pineapples, and results obtained.
SMOOTH CAYENNE.

Experiment and lot No.	Date.	Weight of pulp.	Inter-val of first drying.	Weight of partly dried pulp.	Loss in weight.	Sugar added.			Time in contact with sugar.	Weight of sugared pulp.	Weight of sugar and sirup.	Inter-val of final drying.	Yield of dried slices.		Yield of sirup (on basis of fresh pulp).	Solids in sirup (calculated as sugar).	Sugar in sirup.
						Weight.	On basis of partly dried pulp.	On basis of original pulp.					Grams.	Hours.			
Experiment No. 3:	1909.	Grams.	Hours.	Grams.	Per ct.	Grams.	Per ct.	Per ct.	Hours.	Grams.	Grams.	Hours.	Grams.	Per ct.	Per ct.	Per ct.	
Lot No. 1 a.....	August 12.....	928	0 ¹	1,074	38.6	464	50	30.7	20	775	617	12	296	31.9	66.5	50.0	Little.
2 a.....	do.....	1,750	2 ¹	1,978	44.1	537	50	27.9	18	991	620	12	296	31.9	66.5	50.0	Do.
3 a.....	do.....	1,750	3	3,457	45.7	489	50	27.9	17	947	520	12	448	25.6	35.4	58.9	Do.
4 b.....	do.....	1,750	3	951	45.7	239	25	13.6	17	907	282	12	398	22.4	29.7	63.4	Considerable.
5 c.....	do.....	1,750	5	694	60.3	347	50	19.8	15	707	334	10 ¹	392	22.4	16.2	47.8	Very little.
6 d.....	do.....	1,750	5	670	61.7	167.5	25	9.6	15	670	167.5	10 ¹	350	20.0	19.1	66.1	Much.
7 e.....	do.....	1,750	6	550	69.6	275	50	13.7	14	654	171	10 ¹	368	21.0	9.6	58.5	Do.
															9.8	63.3	Very much.

RED SPANISH.

Experiment No. 4:	August 28.....	1,353	4	392	71.1	156.8	40	11.55	42	469	79	3	337	24.8	5.9	.....
5.....	August 30.....	10,900	6	3,407	68.5	1,703.5	50	15.77	16	3,730	1,371	5	2,645	24.3	12.7	.....
6.....	October 15.....	11,455	6	3,457	69.8	1,383	40	12.07	14	3,770	1,070	5	2,405	21.0	9.3	.....
7.....	do.....	9,680	6	2,870	70.3	1,148	40	11.86	42	2,961	1,057	4 ¹	1,975	20.4	10.9	.....
Experiment No. 8:	October 19.....	1,500	9	357	76.3	180	.....	12.0	137	486	51	4 ¹	370	24.7	3.4	.....
Lot No. a-1.....	do.....	1,500	9	314	79.1	180	.....	12.0	137	.....	.....	4 ¹	418	27.9	.....	.....
a-2.....	do.....	1,500	9	329	78.1	180	.....	12.0	137	.....	.....	4 ¹	420	28.0	.....	.....
a-3.....	do.....	1,500	9	444	70.4	180	.....	12.0	137	454	170	4 ¹	306	20.4	11.3	.....
a-4.....	do.....	2,155	6	570	73.6	258.6	6	12.0	137	674	155	4	479	22.2	7.2	.....
b-1.....	do.....	1,500	9 ¹	368	75.5	180	.....	12.0	137	.....	.....	4	451	30.1	.....	.....
b-2.....	do.....	1,500	9 ¹	363	75.8	180	.....	12.0	137	.....	.....	4	452	30.1	.....	.....
b-3.....	do.....	1,500	8	360	76.0	180	.....	12.0	137	.....	.....	5	445	29.7	.....	.....
b-4.....	do.....	1,500	8	360	76.0	180	.....	12.0	137	.....	.....	5	424	28.3	.....	.....
b-5.....	do.....	1,935	6	595	69.2	232.2	.....	12.0	137	621.2	206	4	471	24.3	10.6	.....

^a Very palatable, but inferior in flavor and texture to lots 4, 5, 6, and 7.

^b Better flavored than Nos. 1, 2, or 3, a personal preference for No. 4 rather than No. 7, because the former is more acid.

^c Better texture than No. 4, but sweeter.

^d Texture inferior to No. 5 and flavor not so good as No. 4.

^e Best, less acid than No. 4.

^f Yield after soaking in sirup was 24.15 per cent.